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Stygobitic oligochaetes (Annelida, Clitellata) in Poland with remarks on their distribution in Central Europe

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Abstract

In Poland eleven stygobitic species have been found, whereas in Central Europe their number reached 23 species. Lumbriculidae are represented by 10 species, Enchytraeidae by seven, Naididae by three, whereas Dorydrilidae and Lumbricidae by two and singular species, respectively. Some species are known from Central Europe exclusively, but majority of them have wider distribution.

Keywords

Subterranean waters, invertebrate fauna

To the memory of my friend dr. Beatrice Sambugar, who encouraged me to prepare this lecture for the symposium entitled "Subterranean Aquatic Annelida", which took place during the 20th International Conference on Subterranean Biology in Postojna (2010).

Introduction

Taking into account their morphological features stygobitic and stygoxenic oligochaete species are indistinguishable. Therefore for this taxonomical group the attribution to stygobionts is based on species distribution. Species found exclusively in subterranean waters (including shallow groundwater sensu Schmidt and Hahn (2012)) are treated as

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stygobionts. Sometimes they could be found in benthic samples also, mainly in springs and occasionally in running waters during low water level periods when rivers are fed directly by underground waters (Allan 1995). In such a situation other stygobionts, for example *Niphargus tatrensis* can be also found (Dumnicka 2005). Among oligochaetes there are many stygophilic species that live and reproduce successfully in surface and subterranean waters whereas stygoxenic species could survive for some time in underground waters but do not reproduce effectively in this environment.

The studies on oligochaetous annelids in subterranean waters of Poland as well as other countries of Central Europe: Czechoslovakia (now Czech Republik and Slovakia), Germany and Hungary started many years ago (Vejdovsky 1882, Lengersdorf 1929, Mohr 1929, Dudich 1932, Stammer 1936, Hrabě 1937, 1942), but generally they were done sporadically and in restricted areas. Nevertheless successive studies allowed to add subsequent species to the list of stygobitic oligochaetes or to find new localities of their occurrence. The state of knowledge about stygobitic oligochaetes was first summarized by Juget and Dumnicka (1986) and recently by Des Châtelliers et al. (2009). Moreover information that accumulated in the last years and some data not considered by Des Châtelliers et al. (2009) was taken into account in the present study: for Austria – paper by Danielopol and Pospisil (2001), for Czech Republik - by Hrabě (1981) and Schenkova et al. (2010), for Germany – by Stein et al. (2012), for Slovakia – by Šporka (1992) and Bitušik et al. (2010), for Poland – by Dumnicka (1998, 2000, 2005, 2009a,b) and Dumnicka and Koszałka (2005).

The current list of stygobitic oligochaete species from Poland and Central Europe is presented and the origin of species known exclusively from Central European countries is discussed. The probable ways of recolonisation after the last glaciation period by some species known from southern Europe is also discussed.

Results

Species distribution in Poland

At present eleven stygobitic species are known from Polish territory (Table 1), the majority of them was found in one geographical region. Some of them were collected from a very restricted area e.g. in one or two closely situated localities and in a very small number of specimens, for example *Trichodrilus spelaeus* – one individual in a pool situated on the bottom of an adit in Klecienko (Sudetes) (Moszyński 1936); *T. pragensis* – a few individuals in two caves in Sudetes (Dumnicka 2000), *Haber zavreli* - two individuals in two wells in Beskidy Mts (Kasprzak 1973) and *Fridericia dissimilis* - seven mature individuals in an intermittent spring in Sudetes (Dumnicka 1998).

The others, known from a limited area in Poland formed significant part of oligochaete taxocens, e.g. *Gianius aquaedulcis* in three closely situated springs located in Warta drainage area (Dumnicka 2009a) and *Enchytraeus polonicus* in a few caves of Kraków Częstochowa Upland (Dumnicka 1981). Among species known from singular

Table 1. Distribution of stygobitic oligochaetes in Poland.

Species	Localities	Habitats	References
Family Lumbriculidae			
Trichodrilus cernosvitovi Hrabě	Tatras, Pieniny Mts., K-Cz Up.	interstitial waters, springs	Kasprzak 1979, Dumnicka 2000, 2005
Trichodrilus moravicus Hrabě	Tatras, Sudetes, Pieniny Mts., Beskidy Mts.	interstitial and cave waters	Kasprzak 1979, Dumnicka 2000, 2009b
Trichodrilus pragensis Vejdovský	Sudetes	cave waters	Dumnicka 2000
Trichodrilus spelaeus Moszyński	Sudetes	locus typicus only (an adit)	Moszyński 1936
Family Naididae			
Rhyacodrilus subterraneus Hrabě	Mazurskie Lakeland	interstitial waters	Dumnicka and Koszałka 2005
Gianius aquaedulcis (Hrabě)	K-Cz. Up.	springs	Dumnicka 2009a
Haber zavreli (Hrabě)	Beskidy Mts.	phreatic waters	Kasprzak 1973
Family Enchytraeidae			
Cernosvitoviella parviseta Gadzińska	Tatras, Sudetes, Beskidy Mts., Pd-W. Lowland	cave and phreatic waters	Dumnicka 2000, 2009b
Enchytraeus dominicae Dumnicka	Tatras, Sudetes, K-Cz Up. Święt. Mts Pd-W. Low.	cave, phreatic, interstitial waters and springs	Dumnicka 2000
Enchytraeus polonicus Dumnicka	K-Cz Up.	wet sediments and cave waters	Dumnicka 1981
Fridericia dissimilis Dumnicka	Sudetes	springs	Dumnicka 1998

Abbreviations: K-Cz Up.: Kraków –Częstochowa Upland; Pd-W. Low.: Południowowielkopolska Lowland; Święt. Mts.: Świętokrzyskie Mts.

localization only *Rhyacodrilus subterraneus* was stated in northern Poland (Mazurian Lakeland), in interstitial waters of a small stream (Dumnicka and Koszałka 2005). In contrast, some other species, such as *Enchytraeus dominicae*, *Cernosvitoviella parviseta*, *Trichodrilus moravicus* and *T. cernosvitovi* are widely distributed in underground water bodies of various categories (Dumnicka 2000). Up to now all enchytraeids (4 species) and *Trichodrilus spelaeus* were found only in Poland.

Species distribution in Central Europe

The number of stygobitic oligochaete species known from separate countries of Central Europe varying from two in Austria to eleven in Poland (Fig. 1). This number likely reflects research effort rather than the true diversity of stygobitic species in each country.

The list of stygobitic oligochaetes found at present in Central Europe is not long – it contains 23 species (Table 2) among them five (mainly enchytraeids) are known from Poland exclusively. Family Lumbriculidae is represented in these countries by 10 species and Enchytraeidae by seven, moreover Naididae, Dorydrilidae and Lumbricidae are represented by a few or singular species.

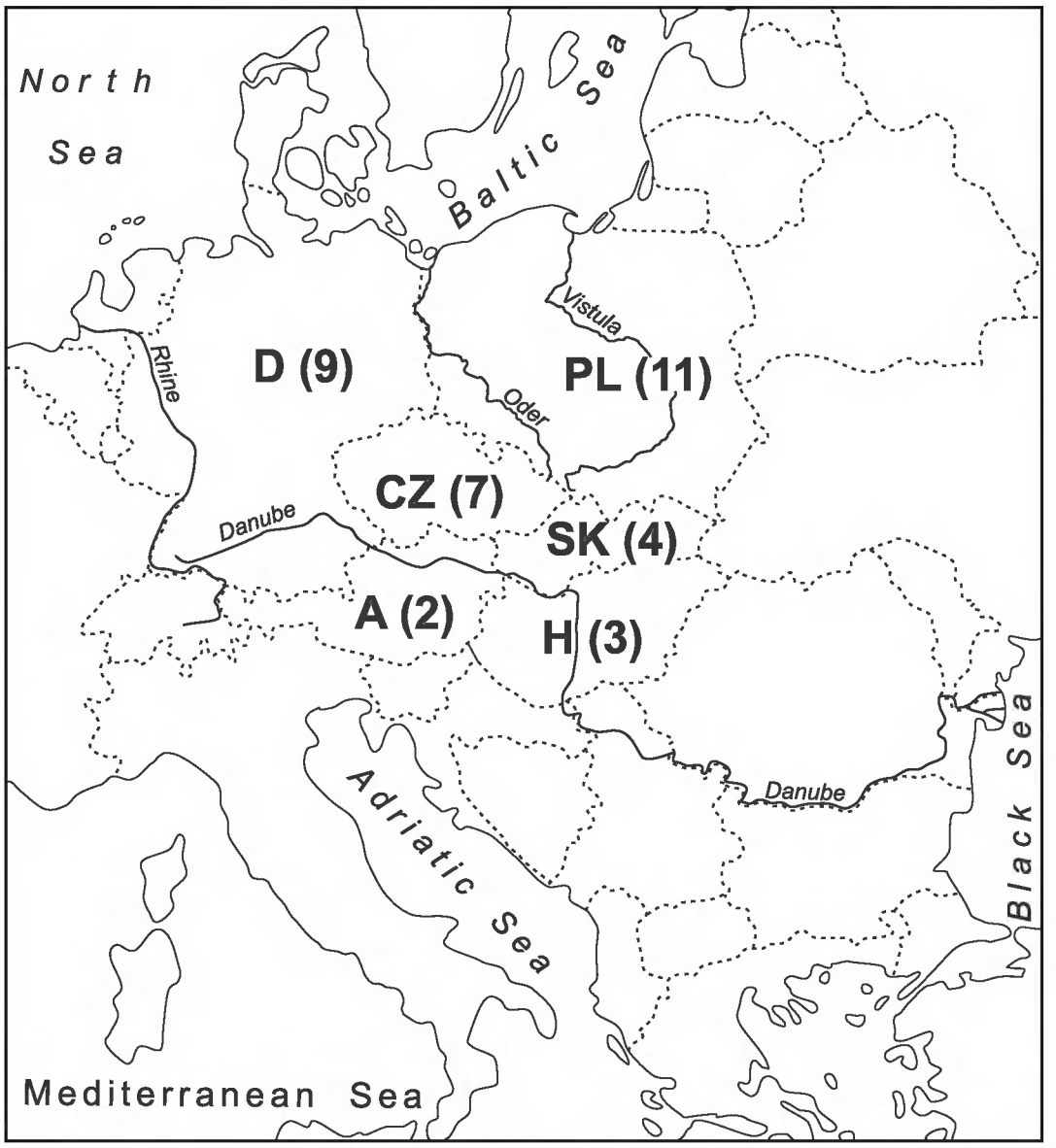

Figure 1. Number of stygobitic oligochaete species known from the countries of Central Europe.

Among stygobitic oligochaete fauna studied in all Central European countries some endemic species (e.g. known exclusively from one geographic region in one country) have been encountered. They are represented by: the above-mentioned *Trichodrilus spelaeus* (from Poland), *Helodrilus mozsaryorum* (Baradla cave, Hungary) (Zicsi et al. 1999) and *Stylodrilus absoloni* (Moravian Karst, Czech Republik) (Hrabě 1981). It seems that *Dorydrilus tetrathecus*, and *Trichodrilus medius*, both known from a few closely situated localities in Germany (Hrabě 1960) could be also treated as endemics. Moreover, up to now, two *Trichodrilus* species (*T. moravicus* and *T. tatrensis*) (Table 2) are known from a few countries of Central Europe solely. *T. moravicus* is known from various subterranean habitats in three neighboring countries (Table 2), whereas *T. tatrensis* was found mainly in bottom samples of some streams flowing below the caves in Slovakian part of Tatra Mts. (Hrabě 1981) and in subterranean waters in Germany (Hrabě 1960). The remaining Lumbriculidae and all Naididae species known from Central Europe have wider distribution: Lumbriculidae and *Gianius aquaedulcis* are known mainly from southern Europe whereas *Haber zavreli* and *Dorydrilus michaelseni* from Great Britain also (Table 2). The distribution of *Rhyacodrilus subterraneus* is dissimilar – this species is known from subterranean waters of Central Europe and Belgium (Martin et al. 2009), and from cold surface waters of the northern part of this

continent (Erséus et al. 2005). It was also found in mountain streams of France and Spain (see Dumnicka and Koszałka 2005).

The studies on Enchytraeidae from the discussed environment were only done in three central European countries: Hungary, Poland and recently in Germany (Stein et al. 2012). Stygobitic species found in these countries belong to aquatic (*Cernosvitoviella*) or semi-aquatic, as well as terrestrial genera (*Enchytraeus, Enchytronia, Fridericia*) and they have limited distribution (Table 2).

Table 2. Distribution of stygobitic oligochaetes known from Central Europe. References concerning species distribution in Poland are in Table 1.

Species	Found in Europe		Habitat	References
	central	western		
Family Lumbriculidae				
Trichodrilus cernosvitovi Hrabě	PL	B, F, RO, SLO	int., spr., ben.	Des Châtelliers et al. 2009, Giani et al. 2011
- *medius* Hrabě	D		int., phr.	Hrabě 1960
- *moravicus* Hrabě	PL, CZ, SK		cav., int., phr.	Hrabě 1981
- *pragensis* Vejdovský	PL, D, CZ	RO, F, E, SLO	cav. int., phr.	Dumnicka 2000, Giani et al. 2011
- *strandi* Hrabě	CZ, SK	I,F,SLO,HR,E	cav. int. spr. ben.	Schenkova et al. 2010, Achurra and Rodriguez 2008
- *tatrensis* Hrabě	D, SK		int., phr., ben.	Šporka 1992, Bitušik et al. 2010
- *tenuis* Hrabě	D, A	F, E, SLO	int. phr.	Des Châtelliers et al. 2009, Giani et al. 2011
- *spelaeus* Moszynski	PL		art. c.	
Stylodrilus absoloni (Hrabě)	CZ		cav. int.	Hrabě 1981
Guestphalinus wiardi (Michaelsen)	D	SLO	cav. int.	Des Châtelliers et al. 2009
Family Dorydrilidae				
Dorydrilus tetrathecus Hrabě	D		phr.	Hrabě 1960
- *michaelseni* Piguet	D, A	F,GB, I,CH	int. cav., ben.	Juget and Dumnicka 1986
Family Naididae				
Gianius aquaedulcis Hrabě	D, PL	F, I, E	int., phr. spr., ben.	Des Châtelliers et al. 2009
Haber zavreli Hrabě	PL, CZ, SK	I, SLO	int. cav. phr.	Hrabě 1981, Giani et al. 2011
Rhyacodrilus subterraneus Hrabě	PL, D, CZ	N, F, E, S, B	int. phr. ben.	Dumnicka and Koszałka 2005
Family Lumbricidae				
Helodrilus mozsaryorum (Zicsi)	H		cav.	Zicsi et al. 1999
Family Enchytraeidae				
Cernosvitoviella aggtelekiensis Dozsa-Farkas	H		cav.	Zicsi et al. 1999
C. parviseta Gadzińska	PL		cav. phr.	
Enchytraeus dominicae Dumnicka	PL		cav. phr. int. spr.	
- *polonicus* Dumnicka	PL		cav.	
- *bohemicus* Dumnicka	CZ		art. c..	Dumnicka 1996
Enchytronia christenseni Dozsa-Farkas	H		cav.	Zicsi et al. 1999
Fridericia dissimilis Dumnicka	PL		spr.	

Abbreviations: ben. – benthos; cav. – cave waters; int. – interstitial waters; phr. – phreatic waters (wells); art. c. - artificial cavities; spr. - springs.

Discussion

The state of knowledge on stygobitic oligochaete fauna in each of the studied countries of Central Europe varies. Aquatic oligochaete fauna was not studied in Hungary whereas there is plenty of information concerning distribution of such fauna in subterranean waters of Germany, Czech Republic, Slovakia and southern part of Poland. Representatives of Enchytraeidae family were studied only in Poland, Hungary and recently in Germany.

Although the diversity of aquatic subterranean oligochaete fauna in Central Europe is distinctly smaller than in Mediterranean countries (Giani et al. 2001, Des Châtelliers et al. 2009, Giani et al. 2011, Achurra and Rodriguez 2008) there are some stygobitic species, known exclusively from this region. Perhaps some of them are true endemics or they have not been found yet in other geographic regions. The widening of the distribution area as a result of intensive studies can be seen in the case of *Guestphalinus wiardi*, known for many years exclusively from Germany and then found in Slovenia by Hrabě (1973). Stygobitic oligochaete species from family Dorydrilidae (*D. tetrathecus*) and Lumbriculidae such as *Trichodrilus moravicus, T. medius*, *T. tatrensis, T. spelaeus* and *Stylodrilus absoloni*, known only from subterranean waters of Central Europe probably diversified in this region before the Tertiary or during the warm Pleistocene periods, when that area was not glaciated, and they survived in singular or several refugia.

Within the genus *Trichodrilus* some of the species have high similarity of various anatomical structures (including genital organs) demonstrating their close relationship to other species living both in epigean and hypogean waters of small, separated areas. Molecular studies should allow to establish the degree of their separation (autonomous or sister species, or same species with some morphological and anatomical differences).

The rarity of stygobitic oligochaete species occurrence makes all studies on their distribution, speciation and ecology very difficult. They are usually found in an extremely small number of samples taken from subterranean waters and even the confirmation of species occurrence and findings of new localities are very difficult. During the studies of 261 localities in Slovenia (Giani et al. 2011) among 19 stygobitic oligochaete species known earlier from this country, the occurrence of only three of them was confirmed. Moreover, ten other stygobionts were found on one to eight sampling stations and *Trichodrilus pragensis* - the most frequently found species - was observed at ten sampling stations (Giani et al. 2011). During large-scale studies on subterranean invertebrate fauna from various geographical regions in Germany, only *Dorydrilus michaelseni* was found (Stein et al. 2012) beside epigean oligochaete species.

The majority of stygobitic species found in Central Europe (except for Enchytraeidae) is known from southern Europe. They could have recolonized subterranean waters of Central Europe after glacial/interglacial periods along water courses - especially along the Danube River. Its catchment area covers large parts of Czech Republic, Slovakia, Germany and Austria. Such migration towards the north part of

Germany along the Rhine River was also possible. Some species could have migrated by underground connections between catchments area of Danube – Oder and Danube –Vistula River in Poland. The presence of such connection is well documented for the Danube – Oder tributaries (Sudetes, Śnieżnik Massive). Kleśnica stream (Poland) is connected by a few kilometers long underground flow with Morava stream (Czech Republic) (Ciężkowski et al. 1996). In the Tatra Mts. such a connection was not confirmed by water-tracing tests, but the existence of such a flow is assumed (Gradziński et al. 2009). The recharge area was located on the southern part of the higher part of the mountains in Slovakia where there is a small sinkhole in the Cicha Valley (catchment of the Danube River). The discharge is probably through resurgences located at the foot of the northern slopes of the mountains in the Bystra Valley in Poland (catchment of the Vistula River). Migration along water courses facilitates wide spreading of species living in hyporheic waters, which usually have wider distribution than those living in phreatic waters. Such a model of species distribution was also mentioned for the genus *Niphargus* (Karaman and Ruffo 1986). Probably the migration of stygobionts of marine origin, mainly known from southern Europe (Sambugar et al. 1999) took place by latitudinal ice – marginal river valleys. The distribution of *Gianius aquaedulcis* in northern and central parts of Germany and Poland could be the example of such a migration.

It seems that the occurrence of some oligochaete species in epigean or hypogean habitats depends on water temperature. For example, *Rhyacodrilus subterraneus* was not found in epigean waters in Poland despite many studies done on their oligochaete fauna, but it lives in epigean streams of northern Europe and mountain streams of France and Spain (see Dumnicka and Koszałka 2005). *Trichodrilus tatrensis* is also known from subterranean (Hrabě 1960) or cold epigean waters (Šporka 1992, Bitušik et al. 2010). Such a species could be named "local" stygobionts in regions where they occur in subterranean waters only.

All the enchytraeid species described and found up to now in the subterranean environment of Central Europe are listed in Table 2, but due to the taxonomic revision began by Schmeltz and Collado (2010) the determination of their exact number is not possible for the moment.

Conclusions

Stygobitic oligochaete fauna of Central Europe is not rich, comprising only 23 species. They were found in various subterranean habitats, but the most frequently in interstitial waters. Some species (14, half of them represents family Enchytraeidae) are known only from Central Europe what suggests their speciation *in situ* and survival during the glacial/interglacial periods in refugia. The species having a wide distribution could have recolonised subterranean waters of Central Europe along water courses from non-glaciated regions of southern Europe.

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